US009346668B1

(12) **United States Patent**
Dreiza et al.

(10) **Patent No.: US 9,346,668 B1**
(45) **Date of Patent: *May 24, 2016**

(54) **MOLDED CAVITY SUBSTRATE MEMS PACKAGE FABRICATION METHOD AND STRUCTURE**

(71) Applicant: **Amkor Technology, Inc.**, Tempe, AZ (US)

(72) Inventors: **Mahmoud Dreiza**, Haute-Savoie (FR); **Andrew Ballantine**, Ain (FR); **Russell Scott Shumway**, Mesa, AZ (US)

(73) Assignee: **Amkor Technology, Inc.**, Tempe, AZ (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

This patent is subject to a terminal disclaimer.

(21) Appl. No.: **14/710,361**

(22) Filed: **May 12, 2015**

Related U.S. Application Data

(63) Continuation of application No. 13/272,096, filed on Oct. 12, 2011, now Pat. No. 9,029,962.

(51) **Int. Cl.**

H01L 27/04	(2006.01)
H01L 21/00	(2006.01)
B81B 7/00	(2006.01)
B81C 1/00	(2006.01)

(52) **U.S. Cl.**
CPC ***B81B 7/007*** (2013.01); ***B81C 1/00301*** (2013.01); *B81B 2207/07* (2013.01); *B81B 2207/095* (2013.01)

(58) **Field of Classification Search**
CPC H01L 27/04; H01L 21/00; G01P 15/125; G01P 15/0802; B81B 2203/0118
USPC 257/415
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

9,029,962 B1 * 5/2015 Dreiza H01L 27/04 257/416

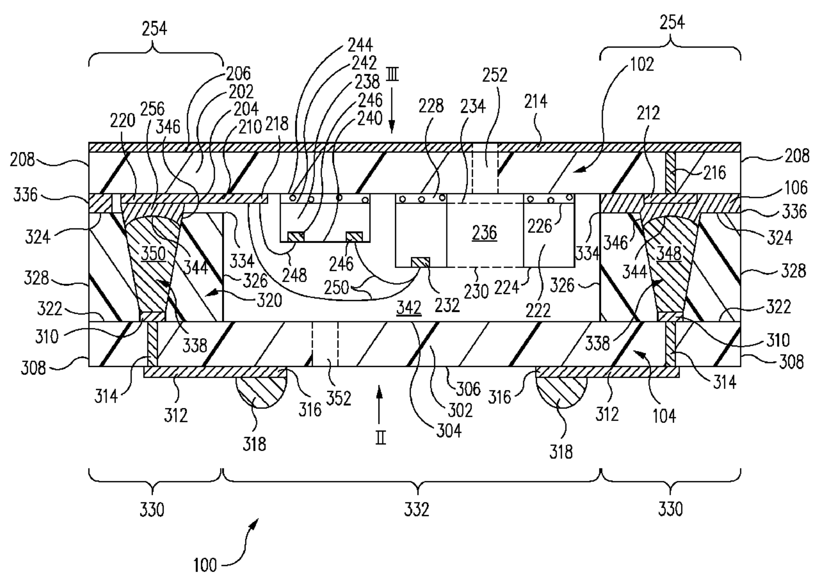
* cited by examiner

Primary Examiner — Monica D Harrison
(74) *Attorney, Agent, or Firm* — McAndrews, Held & Malloy

(57) **ABSTRACT**

Methods and systems for a molded cavity substrate Micro Electro Mechanical Systems (MEMS) package may comprise a MEMS electronic component, a base substrate comprising a first conductive through via, a molded ring coupled to the base substrate, and a lid substrate comprising dielectric material and a metal layer. The molded ring comprises a second conductive through via and a molded cavity, and the MEMS electronic component is located within the molded cavity. The base substrate may comprise a laminate substrate. The lid substrate may comprise a cavity port. A base assembly mounting adhesive may couple an inner surface of the lid to a principal surface of the molded ring. The dielectric material may comprise mold material. The molded ring may comprise mold compound adherent to an outer region of an inner surface of the base substrate with a central region of the base substrate exposed by the molded ring.

20 Claims, 6 Drawing Sheets



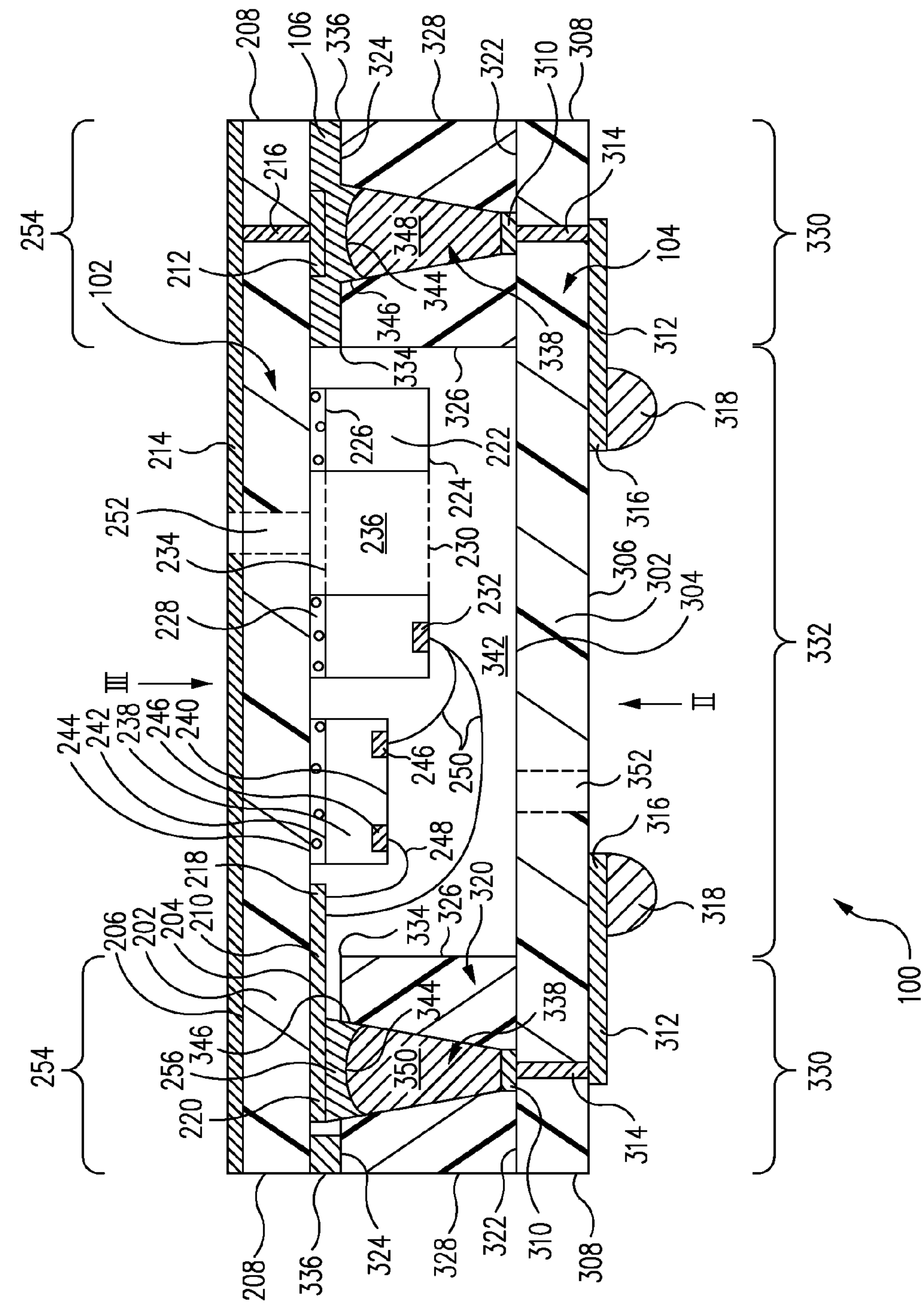

208
106
336
324
328
322
310
308
216
314
254
330
102
212
348
344
104
346
312
338
334
326
318
214
226
222
224
316
252
236
234
230
306
302
228
232
304
342
III
II
244
242
238
246
240
250
352
248
218
210
204
202
206
320
350
256
220
100

FIG. 1

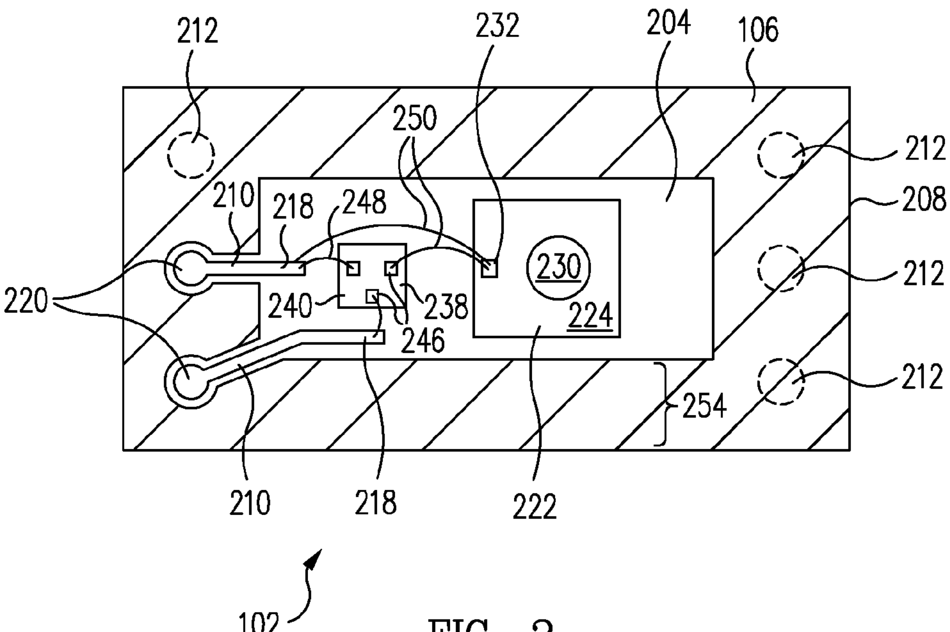

212
232
204
106
250
212
210
218
248
208
230
212
220
240
238
224
246
254
212
210
218
222
102

FIG. 2

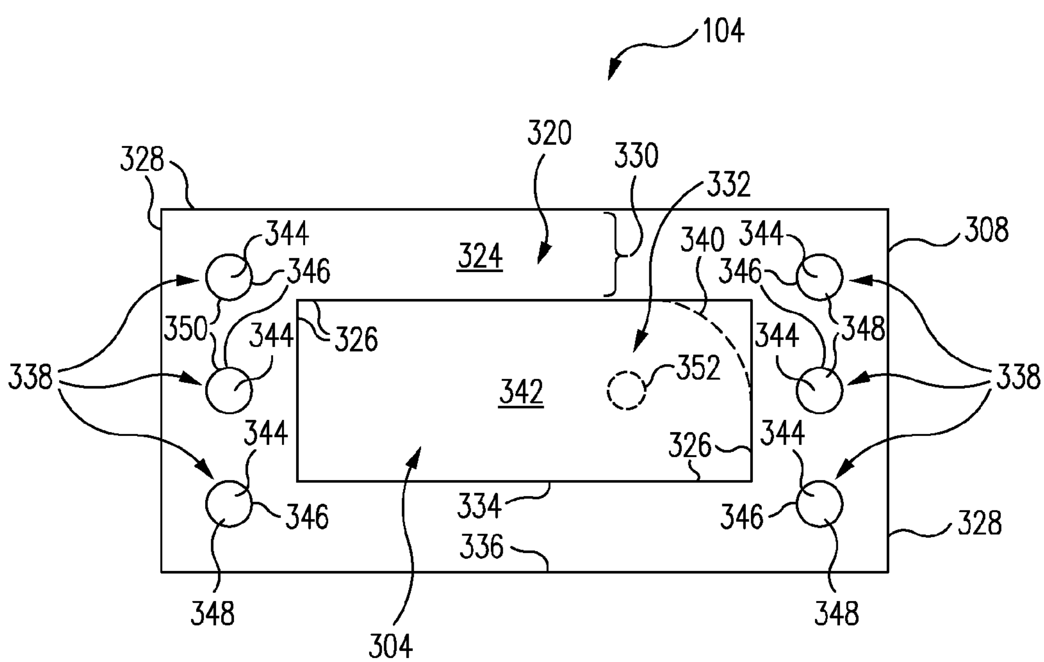

104
320
328
330
332
340
344
308
324
346
344
346
350
344
326
344
348
338
342
352
338
344
326
344
334
346
346
336
328
348
304
348

FIG. 3

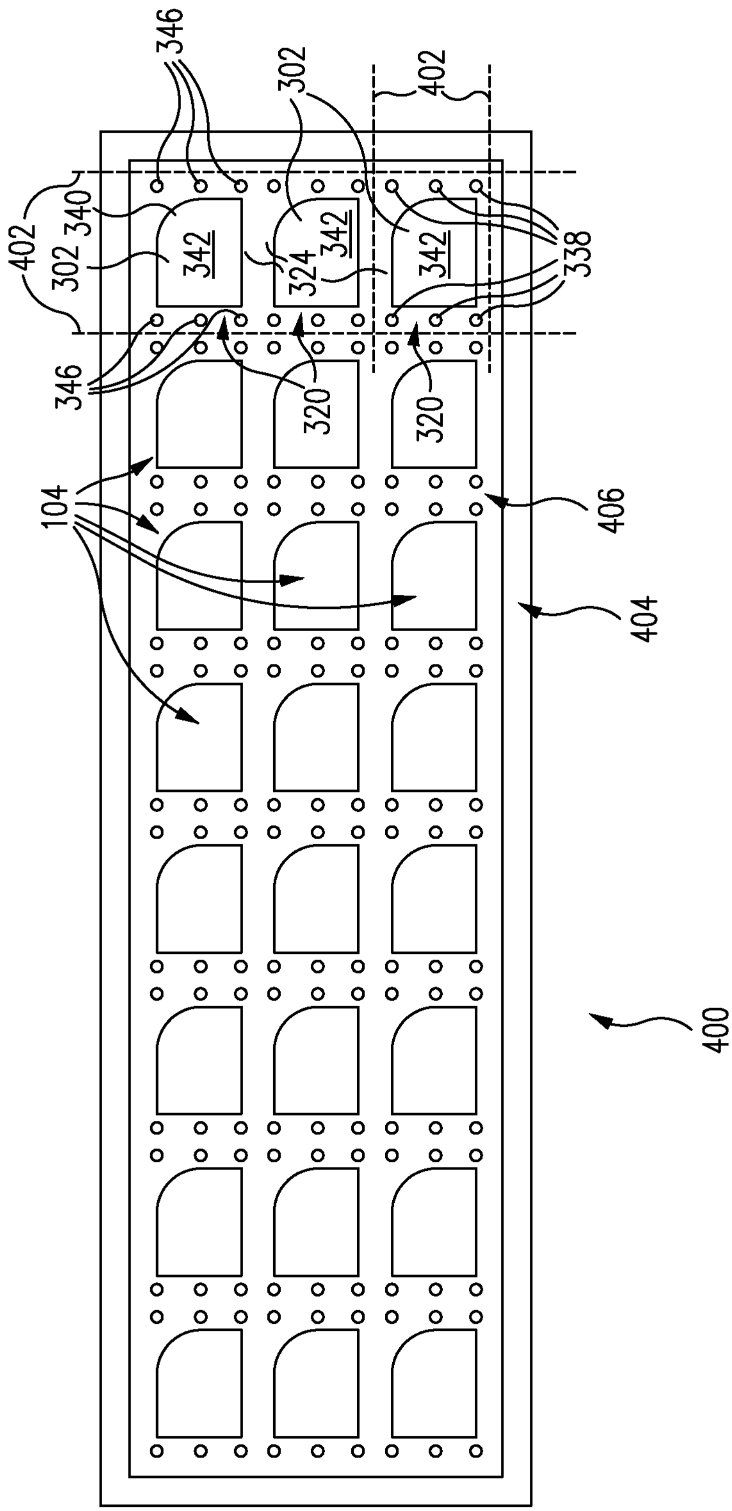
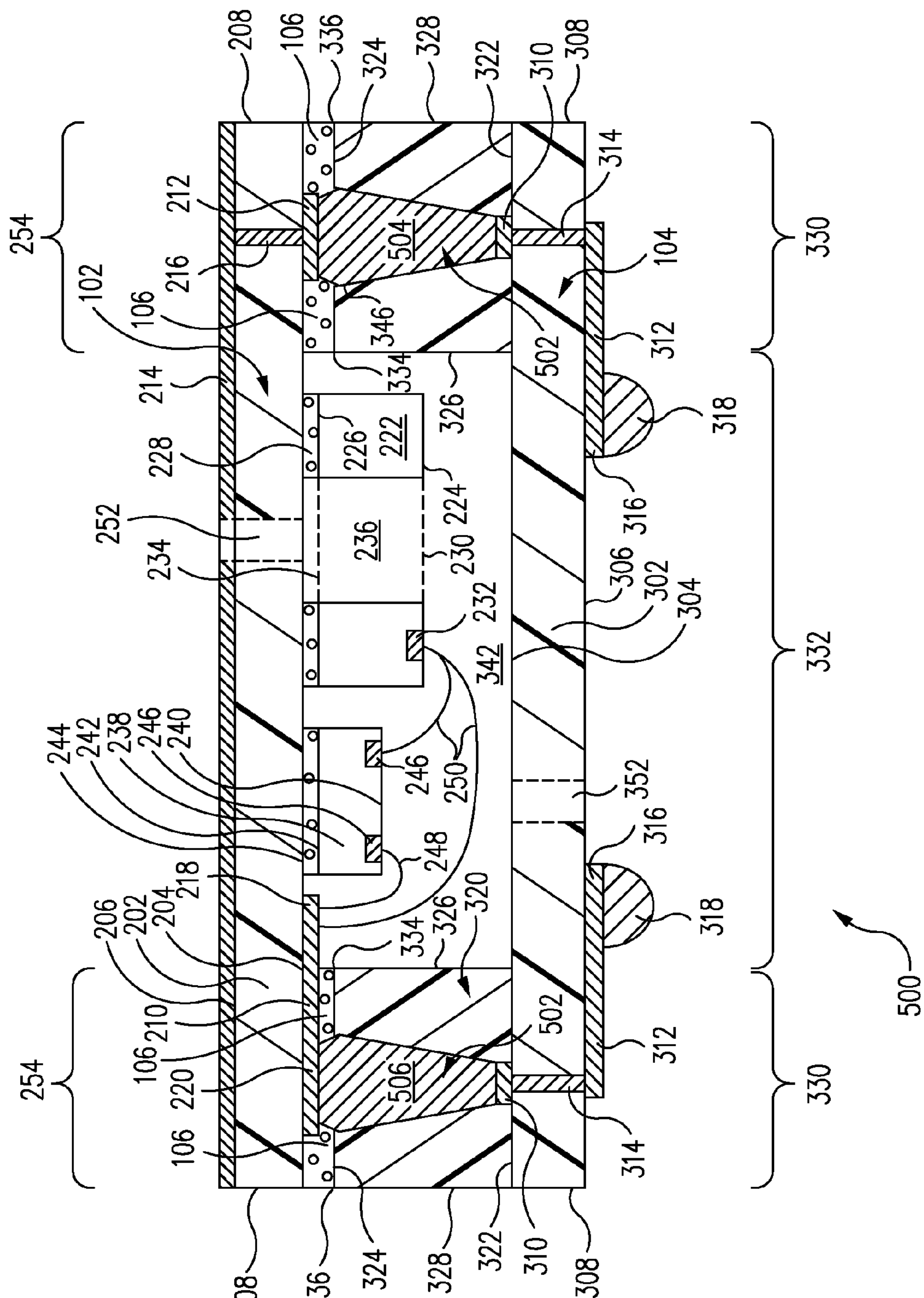

346
302
402
402
302
340
342
342
324
342
338
346
320
320
104
406
404
400

FIG. 4



208
106
336
324
328
322
310
308
254
212
504
314
330
102
216
104
346
502
312
334
214
326
318
228
226
222
224
316
252
236
234
230
306
302
304
232
342
332
244
242
238
246
240
250
352
218
248
320
206
202
204
210
220
506
500

FIG. 5

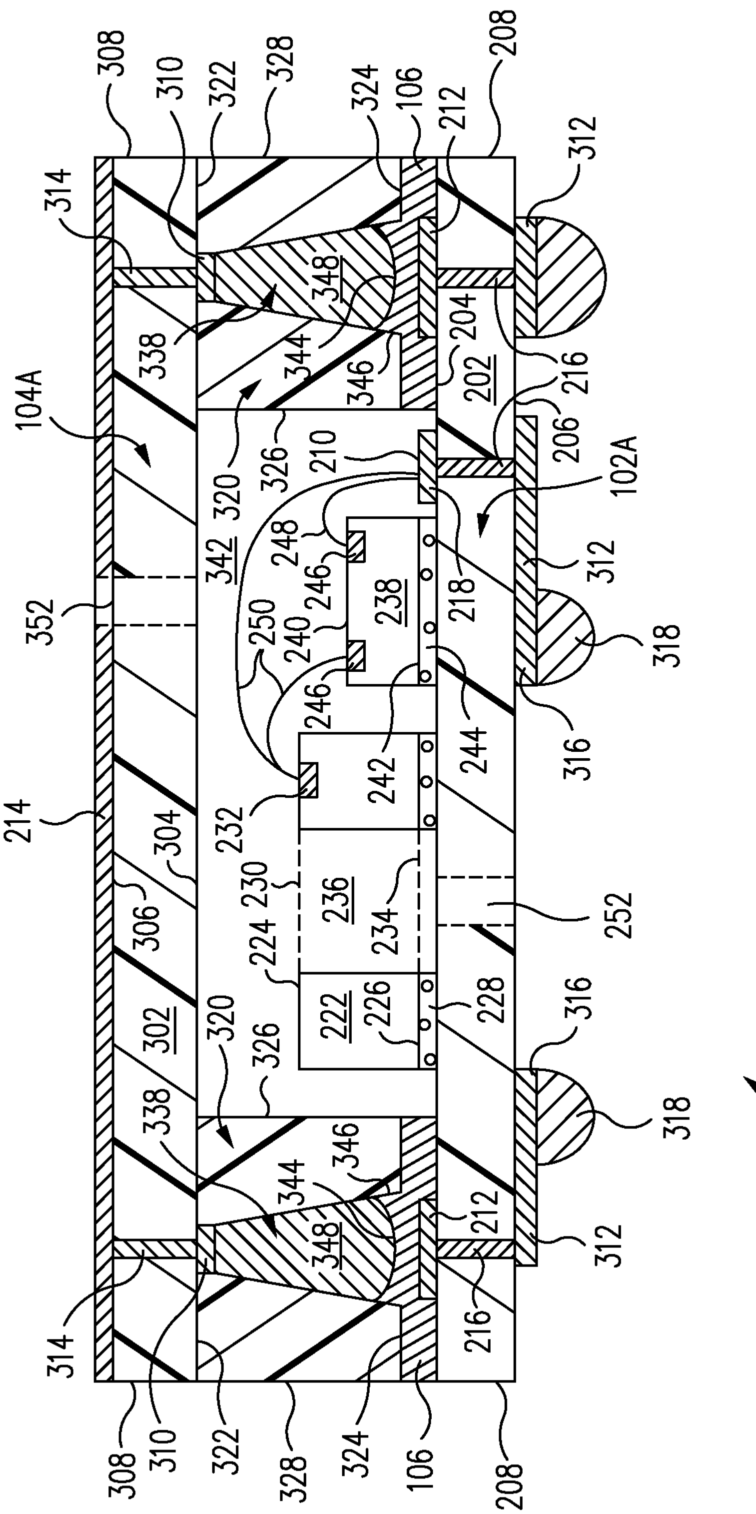


FIG. 6

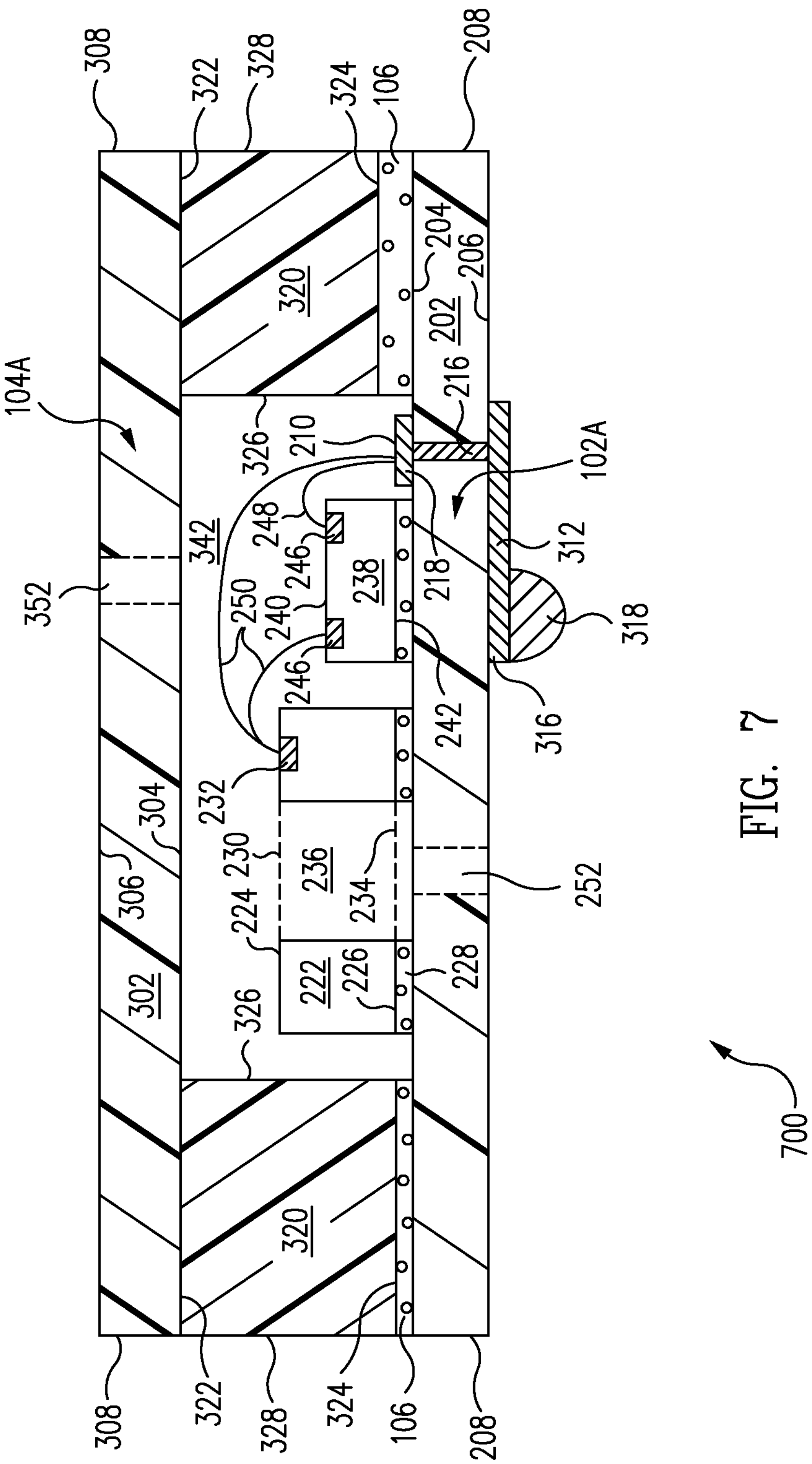

308
322
328
324
106
208
204
206
202
320
216
210
326
104A
102A
342
248
246
238
218
312
352
250
240
318
246
242
316
232
304
306
230
236
234
252
224
302
222
226
228
326
320
322
324
308
328
106
208
700

FIG. 7

MOLDED CAVITY SUBSTRATE MEMS PACKAGE FABRICATION METHOD AND STRUCTURE

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a continuation of application Ser. No. 13/272,096 filed on Oct. 12, 2011, which is hereby incorporated herein by reference in its entirety.

TECHNICAL FIELD

The present application relates to the field of electronics, and more particularly, to methods of forming electronic component packages and related structures.

BACKGROUND

A Micro Electro Mechanical Systems (MEMS) package includes a MEMS sensor die, sometimes called a MEMS electronic component or transducer. As the MEMS sensor die receives external mechanical stimulus such as motion, sound waves or pneumatic pressure, the variations in the stimulus signals are converted to electrical signals.

The MEMS sensor die is located within a cavity of the MEMS package. However, forming the cavity of the MEMS package is relatively complex thus increasing the fabrication cost of the MEMS package.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a cross-sectional view of a molded cavity substrate Micro Electro Mechanical Systems (MEMS) package in accordance with one embodiment;

FIG. **2** is a bottom plan view taken from the direction of arrow II in FIG. **1** of a base assembly of the molded cavity substrate MEMS package in accordance with one embodiment;

FIG. **3** is a top plan view taken from the direction of arrow III in FIG. **1** of a molded cavity substrate of the molded cavity substrate MEMS package in accordance with one embodiment;

FIG. **4** is a top plan view of a molded cavity substrate array of molded cavity substrates in accordance with one embodiment; and

FIGS. **5**, **6**, **7** are cross-sectional views of molded cavity substrate MEMS packages in accordance with various embodiments.

In the following description, the same or similar elements are labeled with the same or similar reference numbers.

DETAILED DESCRIPTION

As an overview and in accordance with one embodiment, referring to FIG. **1**, a molded ring **320** includes a molded cavity **342** of a molded cavity substrate MEMS package **100**. Molded ring **320** is formed by molding a dielectric material directly upon a substrate **302**. As molding is a relatively simple and low cost process, molded ring **320** and thus molded cavity **342** are formed at a minimal cost. This, in turn, minimizes the cost of molded cavity substrate MEMS package **100**.

Now in more detail, FIG. **1** is a cross-sectional view of a molded cavity substrate Micro Electro Mechanical Systems (MEMS) package **100** in accordance with one embodiment. Molded cavity substrate MEMS package **100** includes a base

assembly **102** and a molded cavity substrate **104** joined together by a base assembly mounting adhesive **106**.

FIG. **2** is a bottom plan view taken from the direction of arrow II in FIG. **1** of base assembly **102** of molded cavity substrate MEMS package **100** in accordance with one embodiment. Referring now to FIGS. **1** and **2** together, base assembly **102** includes a substrate **202**.

Substrate **202** includes a dielectric material such as laminate, ceramic, printed circuit board material, or other dielectric material. Substrate **202** includes an inner surface **204**, an opposite outer surface **206**, and sides **208**.

Substrate **202** further includes inner, e.g., first, traces **210** and ground terminals **212** formed at inner surface **204**. Although two inner traces **210** and four ground terminals **212** are illustrated in FIG. **2**, in light of this disclosure, those of skill in the art will understand that molded cavity substrate MEMS package **100** is formed with one or more inner traces **210** and one or more ground terminals **212** depending upon the particular input/output (I/O) required.

Further, substrate **202** includes an electrically conductive ground plane **214** at outer surface **206**. Ground terminals **212** are electrically connected to ground plane **214** by electrically conductive vias **216** extending through substrate **202** between inner surface **204** and outer surface **206**.

Substrate **202** can further include an inner, e.g., first, solder mask at inner surface **204** that protects first portions of inner traces **210** while exposing second portions, e.g., bond fingers **218** and MEMS terminals **220**, of inner traces **210** and exposing ground terminals **212**.

Although a particular electrically conductive pathway is described above, other electrically conductive pathways can be formed. For example, contact metallizations can be formed between the various electrical conductors.

Further, instead of straight though vias **216**, in one embodiment, substrate **202** is a multilayer substrate and a plurality of vias and/or internal traces form the electrical interconnection between ground terminals **212** and ground plane **214**.

Base assembly **102** further includes a MEMS electronic component **222**. MEMS electronic component **222** is a conventional MEMS electronic component, sometimes called a MEMS chip. Accordingly, the features and functions of MEMS electronic component **222** are well known to those of skill in the art. Thus, only a general description of various features and functions of MEMS electronic component **222** are set forth below. Generally, MEMS electronic component **222** includes a mechanical element(s) that produce an electrical signal(s) from external excitations.

For purposes of illustration, MEMS electronic component **222** will be illustrated and described as an acoustical microphone, e.g., a silicon microphone, although can be another type of MEMS electronic component such as a pressure sensor, an optical sensor, a gyroscope, an accelerometer, a stress sensitive non-sensor device, or other MEMS electronic component as discussed further below.

In accordance with this embodiment, MEMS electronic component **222** includes a frontside surface **224** and an opposite backside surface **226**. Backside surface **226** is mounted to inner surface **204** of substrate **202** with an adhesive **228**.

MEMS electronic component **222** further includes a moveable compliant diaphragm **230** and one or more bond pads **232** formed at frontside surface **224**. MEMS electronic component **222** further includes a rigid perforated backplate **234** at backside surface **226**.

MEMS electronic component **222** further includes an aperture **236** extending through MEMS electronic component **222** and between frontside surface **224** and backside surface **226**. More particularly, aperture **236** extends between and separates diaphragm **230** and backplate **234** such that diaphragm **230** and backplate **234** form a capacitor.

As described further below, during operation, sound waves (or pressure waves in other embodiments) move diaphragm **230** thus causing changes in the capacitance between diaphragm **230** and backplate **234**. An electrical signal corresponding to the capacitance variations is output on bond pads **232**.

Base assembly **102** further includes a converter electronic component **238**. Converter electronic component **238** is a conventional converter electronic component, sometimes called an Application Specific Integrated Circuit (ASIC) chip. Accordingly, the features and functions of converter electronic component **238** are well known to those of skill in the art. Thus, only a general description of various features and functions of converter electronic component **238** are set forth below. Generally, converter electronic component **238** converts the signals(s) from MEMS electronic component **222** as required for the particular application.

Converter electronic component **238** includes a frontside, e.g., active, surface **240** and an opposite backside, e.g., inactive, surface **242**. Backside surface **242** is mounted to inner surface **204** of substrate **202** with an adhesive **244**. Frontside surface **240** includes bond pads **246**.

Bond pads **246** of converter electronic component **238** are electrically connected to respective bond fingers **218** of inner traces **210** with electrically conductive bond wires **248**.

In accordance with another embodiment, converter electronic component **238** is mounted in a flip chip configuration. Illustratively, flip chip bumps, e.g., solder, forms the physical and electrical interconnection between bond pads **246** of converter electronic component **238** and bond fingers **218** of inner traces **210**. Optionally, an underfill is applied between converter electronic component **238** and substrate **202**.

In accordance with yet another embodiment, molded cavity substrate MEMS package **100** is formed without converter electronic component **238**. Illustratively, the functionality of converter electronic component **238** is incorporated into MEMS electronic component **222**. Accordingly, a separate converter electronic component **238** is unnecessary and not provided.

Bond pads **232** of MEMS electronic component **222** are electrically connected to respective bond fingers **218** of inner traces **210** with electrically conductive bond wires **250**. Optionally, one or more of bond pads **232** of MEMS electronic component **222** are electrically connected to respective one or more bond pads **246** of converter electronic component **238** with bond wires **250**.

Accordingly, bond pads **232** of MEMS electronic component **222** are electrically connected to respective bond fingers **218** of inner traces **210**, to respective bond pads **246** of converter electronic component **238**, or to both respective bond fingers **218** of inner traces **210** and respective bond pads **246** of converter electronic component **238**. Generally, bond pads **232** of MEMS electronic component **222** are electrically connected to respective bond fingers **218** of inner traces **210** either directly by bond wires **250** or indirectly through converter electronic component **238**.

Substrate **202** further includes a base assembly port **252**. Base assembly port **252** is an aperture, sometimes called an opening or hole, extending through substrate **202** between outer surface **206** and inner surface **204** including through ground plane **214**. Base assembly port **252** extends through substrate **202** to backplate **234** and generally to aperture **236** of MEMS electronic component **222**.

Base assembly port **252** is in fluid communication with aperture **236** of MEMS electronic component **222** and thus with diaphragm **230** of MEMS electronic component **222**. As used herein, regions are in fluid communication when they are directly connected to one another without an intervening structure such that fluid, e.g., air, and sound can freely move from one region to the other.

Accordingly, during use, sound travels through base assembly port **252**, passes through backplate **234**, through aperture **236** and moves diaphragm **230**. As described above, the motion of diaphragm **230** from the sound is converted into an electrical signal that is output on bond pads **232**.

Molded cavity substrate MEMS package **100** further includes molded cavity substrate **104**. FIG. **3** is a top plan view taken from the direction of arrow III in FIG. **1** of molded cavity substrate **104** of molded cavity substrate MEMS package **100** in accordance with one embodiment.

Referring now to FIGS. **1**, **2**, and **3** together, molded cavity substrate **104** includes a substrate **302**. Substrate **302** of molded cavity substrate **104** is sometimes called a first substrate and substrate **202** of base assembly **102** is sometimes called a second substrate.

Substrate **302** includes a dielectric material such as laminate, ceramic, printed circuit board material, or other dielectric material. Substrate **302** includes an inner surface **304**, an opposite outer surface **306**, and sides **308**.

Substrate **302** further includes inner terminals **310** formed at inner surface **304**. Further, substrate **302** includes outer traces **312** at outer surface **306**. Inner terminals **310** are electrically connected to outer traces **312** by electrically conductive vias **314** extending through substrate **302** between inner surface **304** and outer surface **306**.

Outer traces **312** include lands **316**. In one embodiment, lands **316** are distributed in an array thus forming a Land Grid Array (LGA). Alternatively, interconnection balls **318**, e.g., solder balls, are formed on lands **316** thus forming a Ball Grid Array (BGA). Interconnection balls **318** or, alternatively, lands **316** are used to electrically connect molded cavity substrate MEMS package **100** to a larger substrate such as a printed circuit mother board.

Substrate **302** can further include solder masks at inner and/or outer surfaces **304**, **306**, e.g., that protect first portions of outer traces **312** while exposing second portions, e.g., lands **316**, of outer traces **312** and exposing inner terminals **310**.

Although a particular electrically conductive pathway is described above, other electrically conductive pathways can be formed. For example, contact metallizations can be formed between the various electrical conductors.

Further, instead of straight though vias **314**, in one embodiment, substrate **302** is a multilayer substrate and a plurality of vias and/or internal traces form the electrical interconnection between inner terminals **310** and outer traces **312**.

Molded cavity substrate **104** further includes a molded ring **320**. Molded ring **320** is a cured liquid encapsulant, molding compound, or other dielectric material. In one embodiment, molded ring **320** is formed by molding a dielectric material on inner surface **304** of substrate **302**.

Molded ring **320** includes a substrate surface **322**, a principal surface **324**, inner sidewalls **326**, and outer sidewalls **328**. Substrate surface **322** is parallel to principal surface **324**. Inner and outer sidewalls **326**, **328** extend perpendicularly between substrate surface **322** and principal surface **324**.

Although the terms parallel, perpendicular, and similar terms are used herein, it is to be understood that the described features may not be exactly parallel and perpendicular, but only substantially parallel and perpendicular to within accepted manufacturing tolerances.

Substrate surface **322** directly adheres to inner surface **304** of substrate **302**. Illustratively, molded ring **320** is molded directly to inner surface **304** of substrate **302** such that substrate surface **322** is parallel to and coplanar with inner surface **304** of substrate **302**. In one embodiment, substrate surface **322** is identical in shape to principal surface **324** as described in detail below.

More particularly, substrate surface **322** directly adheres to an outer peripheral region **330** of inner surface **304** of substrate **302** while exposing a central region **332** of inner surface **304** of substrate **302**.

Principal surface **324** is an annular surface in accordance with this embodiment. Principal surface **324** is defined by an inner edge **334** and an outer edge **336** of principal surface **324**. In one embodiment, inner edge **334** and outer edge **336** are rectangular in the top plan view, i.e., in the view of FIG. **3**.

However, in other embodiments, inner edge **334** and/or outer edge **336** can have shapes other than rectangular. For example, to increase the surface area of principal surface **324** to allow more through vias **338** to be formed in molded ring **320**, inner edge **334** can have one or more rounded corners **340** as indicated by the dashed line in FIG. **3**.

Molded ring **320** includes a molded cavity **342**. More particularly, the exposed central region **332** of inner surface **304** of substrate **302** and inner sidewalls **326** define molded cavity **342** of molded cavity substrate **104**.

As set forth above, molded ring **320** is formed by molding a dielectric material directly upon substrate **302**. As molding is a relatively simple and low cost process, molded ring **320** and thus molded cavity **342** are formed at a minimal cost. This, in turn, minimizes the cost of molded cavity substrate MEMS package **100**.

Molded cavity substrate **104** further includes electrically conductive through vias **338**. Through vias **338** extend through molded ring **320** between substrate surface **322** and principal surface **324**. More particularly, through vias **338** are formed on inner terminals **310** and extend perpendicularly upward from inner terminals **310** through molded ring **320**.

In one embodiment, the exposed outer via surfaces **344** of through vias **338** are recessed below principal surface **324**. Illustratively, through vias **338** are formed of pre-attached solder balls on inner terminals **310**. The pre-attached solder balls are overmolded by molded ring **320** to completely cover the pre-attached solder balls. Via apertures **346** are formed in principal surface **324**, e.g., by laser-ablation, to expose the pre-attached solder balls, which thus form through vias **338**.

However, in other embodiments, through vias **338** are formed using other through via formation techniques. For example, via apertures are formed in molded ring **320** to expose inner terminals **310**. These via apertures are filled with an electrically conductive material, e.g., solder, electrically conductive adhesive, or other electrically conductive material, to form through vias **338**. In various embodiments, exposed outer via surfaces **344** of through vias **338** are recessed below or protrude above principal surface **324**.

In yet another embodiment, exposed outer via surfaces **344** of through vias **338** are parallel to and coplanar with principal surface **324**. Illustratively, through vias **338** are formed of pre-attached solder balls on inner terminals **310**. The pre-attached solder balls are overmolded by molded ring **320** to completely cover the pre-attached solder balls. Molded ring **320** may be ground down from principal surface **324** to expose the pre-attached solder balls, which thus form through vias **338** having exposed outer via surfaces **344** parallel to and coplanar with principal surface **324**.

In accordance with the illustrated embodiment, through vias **338** include one or more ground vias **348** and one or more MEMS vias **350**, sometimes called MEMS signal vias **350**. More particularly, ground vias **348** and MEMS vias **350** are identical in structure, i.e., are first and second sets of through vias **338**. However ground vias **348** are electrically connected to ground plane **214** of base assembly **102** as discussed further below. In contrast, MEMS vias **350** are connected to MEMS electronic component **222** and/or to converter electronic component **238** of base assembly **102**.

As illustrated in FIG. **1**, inner surface **204** of substrate **202** of base assembly **102** is mounted to principal surface **324** of molded ring **320** of molded cavity substrate **104** such that ground vias **348** are aligned with ground terminals **212** and MEMS vias **350** are aligned with MEMS terminals **220** of inner traces **210**.

As illustrated in FIGS. **1** and **2**, ground vias **348** are electrically connected to ground terminals **212** by base assembly mounting adhesive **106**. In one embodiment, base assembly mounting adhesive **106** is electrically conductive adhesive, although can be other electrically conductive materials such as solder or paste.

In one embodiment, base assembly mounting adhesive **106** electrically connects ground vias **348** to ground terminals **212** in a many to many relationship. More particularly, all of ground vias **348** are electrically connected to all of ground terminals **212** by base assembly mounting adhesive **106**. For example, base assembly mounting adhesive **106** seals the entire outer periphery **254** of inner surface **204** to the entire principal surface **324** of molded ring **320** while at the same time electrically connecting ground vias **348** to ground terminals **212**.

During operation, the respective interconnection balls **318** connected to ground plane **214** are electrically connected to a reference voltage source, e.g., ground. More particularly, the reference voltage source is coupled from the respective interconnection balls **318** through the respective lands **316**, outer traces **312**, vias **314**, inner terminals **310**, ground vias **348**, base assembly mounting adhesive **106**, ground terminals **212**, vias **216**, and to ground plane **214**.

Ground plane **214** is formed of an electrically conductive material to provide Radio Frequency (RF) shielding or more generally to provide shielding from ElectroMagnetic Interference (EMI). For example, when MEMS electronic component **222** is a silicon (Si) microphone, ground plane **214** shields MEMS electronic component **222** from EMI.

However, in another embodiment where shielding is unnecessary, molded cavity substrate MEMS package **100** is formed without ground plane **214** and without the respective interconnection balls **318**, lands **316**, outer traces **312**, vias **314**, inner terminals **310**, ground vias **348**, base assembly mounting adhesive **106**, ground terminals **212**, and vias **216**. For example, MEMS electronic component **222** is an optical MEMS or pressure sensor that does not require shielding and so ground plane **214** and the associated conductors are not formed. In accordance with this embodiment, base assembly mounting adhesive **106** can be either a dielectric or conductive material.

In another embodiment, MEMS electronic component **222**, sometimes referred to as an electronic component **222**, is a MEMS or non-MEMS sensor that benefits from the low stress cavity environment provided by embodiments as described herein.

Referring again to the embodiment illustrated in FIGS. **1**, **2**, and **3**, base assembly mounting adhesive **106** and thus ground plane **214** is electrically isolated from inner traces **210**. More particularly, base assembly mounting adhesive **106** is patterned around MEMS terminals **220** to avoid contact and electrical interconnection (shorting) therewith.

MEMS vias **350** are electrically connected to MEMS terminals **220** by MEMS via interconnect material **256**. In one embodiment, MEMS via interconnect material **256** is electrically conductive adhesive, although can be other electrically conductive materials such as solder.

In one embodiment, MEMS via interconnect material **256** electrically connects MEMS vias **350** to MEMS terminals **220** in a one to one relationship. More particularly, each MEMS via **350** is electrically connected to a respective MEMS terminal **220** by a respective MEMS via interconnect material **256**.

During operation, signals are propagated to/from the respective interconnection balls **318** and to bond pads **232** of MEMS electronic component **222** and/or to bond pads **246** of converter electronic component **238**. More particularly, signals are propagated to/from the respective interconnection balls **318** through the respective lands **316**, outer traces **312**, vias **314**, inner terminals **310**, MEMS vias **350**, MEMS via interconnection materials **256**, MEMS terminals **220**, inner traces **210**, bond fingers **218**, bond wires **248** and/or bond wires **250**, and to bond pads **232** of MEMS electronic component **222** and/or to bond pads **246** of converter electronic component **238**.

As set forth above, base assembly mounting adhesive **106** seals the entire outer periphery **254** of inner surface **204** to the entire principal surface **324** of molded ring **320**. Accordingly, molded cavity **342** of molded cavity substrate **104** is sealed by base assembly **102** and base assembly mounting adhesive **106**.

MEMS electronic component **222** and converter electronic component **238** are located within molded cavity **342**. As set forth above, in one embodiment, base assembly port **252** extends through substrate **202** to backplate **234** and generally to aperture **236** of MEMS electronic component **222**. In accordance with this embodiment, molded cavity **342** defines a back volume.

In another embodiment, instead of providing base assembly port **252**, a molded cavity substrate port **352** is formed in molded cavity substrate **104**. More particularly, molded cavity substrate port **352** is an aperture, sometimes called an opening or hole, extending through substrate **302** between outer surface **306** and inner surface **304**. Molded cavity substrate port **352** extends through substrate **302** to molded cavity **342**.

Molded cavity substrate port **352** is in fluid communication with molded cavity **342** and thus with diaphragm **230** of MEMS electronic component **222**. In accordance with this embodiment, aperture **236** of MEMS electronic component **222** defines a back volume.

In accordance with another embodiment, molded cavity substrate MEMS package **100** includes both base assembly port **252** and molded cavity substrate port **352**. For example, MEMS electronic component **222** is a differential or gauge pressure sensor that senses the difference in pressure at base assembly port **252** and molded cavity substrate port **352**.

In accordance with another embodiment, molded cavity substrate MEMS package **100** does not include either base assembly port **252** or molded cavity substrate port **352**. For example, MEMS electronic component **222** does not need to be in fluid communication with the ambient environment. For example MEMS electronic component **222** is a gyroscope (gyro), accelerometer, a stress sensitive device, and/or combinations thereof, e.g., includes single or multiple MEMS dies sealed within molded cavity **342**.

As illustrated in FIG. **1**, sides **208** of substrate **202**, outer sidewalls **328** of molded ring **320**, and sides **308** of substrate **302** are parallel to and coplanar with one another. Illustratively, molded cavity substrate MEMS package **100** is formed simultaneously with a plurality of packages in an array or strip. The array or strip is singulated resulting in sides **208**, outer sidewalls **328**, and sides **308** being parallel to and coplanar with one another.

FIG. **4** is a top plan view of a molded cavity substrate array **400** of molded cavity substrates **104** in accordance with one embodiment. Referring now to FIGS. **1** and **4** together, molded cavity substrates **104** are integrally connected together within molded cavity substrate array **400**. Molded cavity substrates **104** are delineated from one another by singulation streets **402**.

In one embodiment, to form molded cavity substrate array **400**, a substrate array **404** of substrates **302** integrally connected together is provided. Pre-attached solder balls are formed on inner terminals **310** of substrates **302**. The pre-attached solder balls are overmolded by a molded ring array **406** of molded rings **320** to completely cover the pre-attached solder balls. Via apertures **346** are formed in molded rings **320**, e.g., by laser-ablation, to expose the pre-attached solder balls, which thus form through vias **338**.

However, in other embodiments, through vias **338** are formed using other through via formation techniques. For example, via apertures are formed in molded rings **320** to expose inner terminals **310** of substrates **302**. The via apertures are filled with an electrically conductive material, e.g., solder, electrically conductive adhesive, or other electrically conductive material, to form through vias **338**.

In yet another embodiment, pre-attached solder balls are formed on inner terminals **310** of substrates **302**. The pre-attached solder balls are overmolded by molded ring array **406** of molded rings **320** to completely cover the pre-attached solder balls. Molded ring array **406** including molded rings **320** are ground down from principal surfaces **324** to expose the pre-attached solder balls, which thus form through vias **338**.

After fabrication of molded cavity substrate array **400** as discussed above, a base assembly **102** is attached to each molded ring **320** in a manner similar to that described above. In one embodiment, a base assembly array including a plurality of base assemblies **102** is attached to molded cavity substrate array **400**. The resulting assembly is then singulated along singulation streets **402** resulting in a plurality of individual molded cavity substrate MEMS packages **100**.

In another embodiment, individual base assemblies **102** are mounted one at a time to each molded ring **320** of molded cavity substrate **400**. The resulting assembly is then singulated along singulation streets **402** resulting in a plurality of individual molded cavity substrate MEMS packages **100**.

In yet another embodiment, molded cavity substrate MEMS packages **100** are fabricated individually. For example, molded cavity substrate **400** is singulated to form a plurality of individual molded cavity substrates **104**. Alternatively, molded cavity substrates **104** are formed individually, e.g., by molding a molded ring **320** upon an individual substrate **302**. In either embodiment, a base assembly **102** is mounted individually to an individual molded cavity substrate **104**.

FIG. **5** is a cross-sectional view of a molded cavity substrate MEMS package **500** in accordance with one embodiment. Molded cavity substrate MEMS package **500** of FIG. **5** is similar to molded cavity substrate MEMS package **100** of FIG. **1** and only the significant differences are described below.

Referring now to FIG. **5**, in accordance with this embodiment, inner terminals **310** are electrically and physically connected to MEMS terminals **220** and ground terminals **212** by electrically conductive solder columns **502**. Solder columns **502** extend from inner terminals **310**, through molded ring

220, and to MEMS terminals 220 and ground terminals 212. Inner terminals 310 are electrically connected in a one to one relationship to MEMS terminals 220 and ground terminals 212 by solder columns 502.

For example, referring now to FIGS. 1 and 5 together, solder balls (not shown) are formed on MEMS terminals 220 and ground terminals 212. These solder balls are placed within via apertures 346 of molded ring 320 and on outer via surfaces 344 of through vias 338 (via apertures 346, outer via surfaces 344, and through vias 338 are illustrated in FIG. 1). The assembly is then heated to reflow, i.e., heat to a melt and then cool to resolidify, these solder balls and through vias 338 to collectively form solder columns 502 as illustrated in FIG. 5.

In accordance with this embodiment, solder columns 502 include one or more ground solder columns 504 and one or more MEMS solder columns 506. More particularly, ground solder columns 504 and MEMS solder columns 506 are identical in structure, i.e., are first and second sets of solder columns 502. However ground solder columns 504 are electrically connected to ground plane 214 of base assembly 102. In contrast, MEMS solder columns 506 are connected to MEMS electronic component 222 and/or converter electronic component 238 of base assembly 102.

Base assembly mounting adhesive 106, e.g., an underfill type dielectric material, surrounds and protects solder columns 502 in one embodiment.

FIG. 6 is a cross-sectional view of a molded cavity substrate MEMS package 600 in accordance with one embodiment. Molded cavity substrate MEMS package 600 of FIG. 6 is similar to molded cavity substrate MEMS package 100 of FIG. 1 and only the significant differences are described below.

Referring now to FIG. 6, in accordance with this embodiment, ground plane 214 is formed on outer surface 306 of substrate 302 of a molded cavity substrate 104A. Further, outer traces 312 are formed on outer surface 206 of substrate 202 of a base assembly 102A.

Ground plane 214 is electrically connected to vias 314, inner terminals 310, and ground vias 348. Note that all the electrically conductive through vias 338 that extend through molded ring 320 in accordance with this embodiment are electrically connected to ground plane 214 and thus are referred to as ground vias 348.

Outer traces 312 are electrically connected to vias 216 and inner traces 210. Outer traces 312 are also electrically connected to vias 216 and ground terminals 212. Ground terminals 212 are electrically connected to exposed outer via surfaces 344 of ground vias 348 by base assembly mounting adhesive 106. However, in another embodiment, inner terminals 310 are directly connected to ground terminals 212 by solder columns similar to solder columns 502 of molded cavity substrate MEMS package 500 of FIG. 5 as described above.

FIG. 7 is a cross-sectional view of a molded cavity substrate MEMS package 700 in accordance with one embodiment. Molded cavity substrate MEMS package 700 of FIG. 7 is similar to molded cavity substrate MEMS package 600 of FIG. 6 and only the significant differences are described below. More particularly, molded cavity substrate MEMS package 700 is formed without ground plane 214 and the associated conductors of molded cavity substrate MEMS package 600. Accordingly, outer traces 312 are connected only to inner traces 210 by vias 216.

Referring now to FIG. 7, molded ring 320 has an absence of through vias or other electrically conductive structures. Principal surface 324 of molded ring 320 is attached to inner surface 204 of substrate 202 by base assembly mounting adhesive 106.

Although specific embodiments were described herein, the scope of the invention is not limited to those specific embodiments. Numerous variations, whether explicitly given in the specification or not, such as differences in structure, dimension, and use of material, are possible. The scope of the invention is at least as broad as given by the following claims.

What is claimed is:

1. An electronic component package comprising:
a Micro Electro Mechanical Systems (MEMS) electronic component;
a base substrate comprising an inner surface, an outer surface, and a first conductive path extending from the inner surface to the outer surface;
a molded ring coupled to the base substrate, the molded ring comprising a top side, a bottom side, a second conductive path extending from the top side to the bottom side, and a molded cavity, the MEMS electronic component being located within the molded cavity; and
a lid coupled to the molded ring, the lid comprising a metal layer.

2. The electronic component package of claim 1, wherein the base substrate comprises a laminate substrate.

3. The electronic component package of claim 1, wherein the lid comprises a cavity port.

4. The electronic component package of claim 1, wherein the lid comprises a dielectric material.

5. The electronic component package of claim 4, wherein the dielectric material comprises mold material.

6. The electronic component package of claim 4, wherein the dielectric material and metal layer of the lid comprise a molded cavity substrate.

7. The electronic component package of claim 1, wherein the molded ring comprises:
mold compound directly adherent to an outer peripheral region of the inner surface of the base substrate, with a central region of the inner surface of the base substrate exposed by the molded ring.

8. The electronic component package of claim 1, wherein the metal layer comprises a ground plane; and
at least one of the first or second conductive paths comprise a through via.

9. The electronic component package of claim 1, wherein the metal layer is electrically coupled to the second conductive path.

10. The electronic component package of claim 1, wherein an aperture extends through the base substrate.

11. An electronic component package comprising:
a package top lid comprising a metal layer and dielectric material;
package sidewalls comprising mold material and forming a molded ring;
a base substrate comprising an inner surface coupled to the molded ring, the base substrate further comprising an inner trace coupled to the inner surface and an outer trace coupled to an outer surface of the base substrate; and
a Micro Electro Mechanical Systems (MEMS) electronic component located within a cavity defined the molded ring.

12. The electronic component package of claim 11, wherein the dielectric material comprises mold material.

13. The electronic component package of 11, wherein a conductive via extends through the molded ring.

14. The electronic component package of claim **13**, wherein the conductive via is electrically coupled to the metal layer in the package top lid.

15. The electronic component package of claim **11**, wherein the metal layer in the package top lid comprises a ground plane.

16. The electronic component package of claim **11**, wherein an electronic component is coupled to the MEMS electronic component and located within the molded ring.

17. The electronic component package of claim **11**, wherein the MEMS electronic component is electrically coupled to the inner trace.

18. The electronic component package of claim **11**, wherein an aperture extends through the base substrate.

19. The electronic component package of claim **11**, wherein the package top lid comprises a cavity port.

20. A method of manufacturing an electronic component package, the method comprising:

molding a dielectric material on a base substrate to form a molded ring, the molded ring comprising a conductive through via and a molded cavity;

providing a Micro Electro Mechanical Systems (MEMS) electronic component within the molded cavity; and

providing a package lid comprising a metal layer, the package lid coupled to the molded ring and the metal layer coupled to the conductive through via.

* * * * *